ANTIBACTERIAL ACTIVITY OF BELILIK (Brucea javanica (L.) MERR) AND BENTA (Wikstroemia androsaemofolia DECNE) TO INHIBIT THE GROWTH OF ENTEROPATHOGENIC BACTERIA

Henny Helmi*, Idha Susanti, Noptiam Asmara Agung, Sadam Kusen

Biology Department, Bangka Belitung University

ABSTRACT

Several native Indonesia plants have been used to prepare traditional medicine since long time ago. One of common diseases in tropical country is diarrhea, it caused by the infection of enteropathogenic bacteria such as Enteropathogenic Escherichia coli, Pseudomonas aeruginosa, Staphylococcus aureus, and Shigella sp. Belilik (Brucea javanica (L.) Merr) and Benta (Wikstroemia androsaemofolia Decne) are herbal that utilized as medicine for diarrhea in Bangka Belitung, Indonesia. Parts of these plants are mostly can be utilized as medicine, such as leaf, root, and fruit. The aims of this study were to investigate the antibacterial activity of ethanol crude extract of B. javanica (root and fruit) and W. androsaemofolia (leaf and fruit) against enteropathogenic bacteria (EPEC, P. aeruginosa, S. aureus, Shigella sp.). Method that used was paper disc diffusion. The results showed that at concentration 10 mg/mL, 20 mg/mL, and 30 mg/mL of B. javanica ethanol extract of both root and fruit could not inhibit the enteropathogenic bacteria, while the ethanol extract of leaf and fruit of W. androsaemofolia were shown inhibition activity on the growth of enteropathogenic bacteria. W. androsaemofolia leaf extract performed the best inhibition activity to the growth of EPEC (20.55±1.5mm) and S. aureus (22.14±4.5mm), it was better than kanamycin performance at the same concentration (30 mg/mL). In addition, ethanol extract of W. androsaemofolia fruit showed the best inhibition activity against Shigella sp. (19.64±1.8mm).

Keywords: antibacterial, Brucea javanica (L.) Merr, enteropathogenic bacteria, Wikstroemia androsaemofolia Decne

INTRODUCTION

Antibiotic resistance has become a global problem in the world recently. One of the cases is the resistance of some infectious pathogenic bacteria that caused enteropathogenic disease, such as EPEC (Enteropathogenic E. coli), Staphylococcus aureus, Pseudomonas aeruginosa, and Shigella sp. Kusmala (2012). Noveria (2012) stated that those bacteria are resist to kanamycin, amoxicillin, chloramphenicol, and tetracycline. The cases of resistance case encourage researchers to find alternative drugs to treat various diseases caused by microbial infection such as medicinal plants exploration. On the contrary to synthetic drugs, natural antimicrobials derived from plant are not associated with negative effects. Furthermore, it has therapeutic potential to treat other diseases (Anand et al., 2011).

The number of researchers that explore natural products in order to develop better drugs against cancer as well as viral and microbial infections is increase dramatically (Srinivasan et al., 2001). Total 80% of world’s population relies on traditional medicines for primary healthcare and most of it involves the utilization of plant extracts (Sandhya et al., 2006). Various plants possess medicinal properties, such as antibacterial properties. Several medicinal plants that have been used today were known by the ancient cultures throughout the world (Zalkia 1975 in Dipankar et al., 2011). Traditional usages of in indigenous society can provide information as the foundation of modern pharmaceutical development (Philip et al., 2009).

Indonesia is known as country with the second highest plant diversity in the world after Brazil (Sampurno 2007). Supported by indigenous cultures that have wide knowledge of traditional medicine, Indonesia possesses high diversity of medicinal plants. Bangka Belitung Islands is one of provinces in Indonesia which rich of folk medicines. Bangka Belitung community commonly utilize local plants such as belilik (B. javanica (L.) Merr) and benta (W. androsaemofolia Decne) to overcome diarrhea. B. javanica is commonly used to treat malaria, amoebic dysentery, vaginal candidiasis, hemorrhoids, intestinal worms, papilloma, and nasopharyngeal cancer. In addition, its root has benefit in malaria treatment, fever, and food poisonous (Adelia, 2010; Dalimarta, 2001). Root and stem mixture is effective for fever and indigestion treatment (Hendrian & Haidah 1999). B. javanica fruit contains saponins and tannins that potential as antibacterial agents, it can be assumed that these compounds also can be found in root (Rahayu et al., 2009). Another plant that Bangka Belitung community use for medicine is W. androsaemofolia. It commonly used as anti-malaria, moreover people also used this plant as cure for diarrhea. W. indica shares the same genus with W. androsaemofolia.
folia, because of that they contain similar active compound such as flavonoid, biflavonoid, coumarins, lignans, essential oils, and polysaccharides (Li et al, 2009). Likewise, this plant allegedly also has antibacterial properties.

As the matter of facts, those medicinal plants are undoubtedly have important value to treatment of several diseases. The antibacterial activity of these plants against enteropathogenic bacteria through in vitro have not clearly revealed yet. Therefore, this study investigated the antibacterial activity of B. javanica and W. androsaemifolia against enteropathogenic bacteria. The aims of this study were to investigate the antibacterial activity of these plants and compare their effectiveness to commercial antibiotic. This study will contribute in new approach of diarrhea treatment.

METHODS

Plant material
Herbals that used in this study were belilik (B. javanica (L). Merr) and Benta (W. androsaemifolia Decne). B. javanica were obtained from Selinding, Pangkalpinang, Bangka Island, while W. androsaemifolia were from Tanjungpandan, Belitung Island Indonesia.

Extraction
Extraction was done by soxhlet method. Each 100 g sample of B. javanica fruit, B. javanica root, W. androsaemifolia leaves, and W. androsaemifolia fruit were crushed separately then soaked in 96% of ethanol and heated to get the perfect extract, at the end of the process, solvent became clear. Solvent then were dried using vacuum rotary evaporator. Total yields of extraction were then measured.

Phytochemical Analysis
Phytochemical components were analyzed qualitatively. Purpose of this analysis was to use investigate active compound contains in fruit and root of Belilik (Brucea javanica (L.) Merr) and W. androsaemifolia leaves and fruit. There are some active compound that have been analyzed in both plants such as alkaloids, flavonoids, phenols, saponins, steroids, tannins, and triterpenoids.

Alkaloids
30 mg of extract were diluted in 10 mL of CHCl3 – NH3 and filtered, filtrate was accumulated into test tube. 3-5 drops of 2M sulfuric acid was added into the filtrate then shook until formed two layers. Acid layer (top layer) was pipetted into another test tube, then Dragendorff reagent was added. Alkaloids will be detected by the formation of orange to reddish brown sediment (Robinson 1995).

Flavonoids
30 mg of extract were added into 100 mL of hot water, boiled for 5 minutes, then filtered. Filtrate was added into 5 mL of 0.05 mg Mg powder and concentrated HCl then shaken vigorously. Positive test was indicated by formation of red, yellow, or orange colour in the (Harborne 1996).

Phenols
10 drops of 1% FeCl3 were added into 30 mg of extract. Phenols were represented by the production of green, red, purple or dark black colour (Harborne 1996).

Saponins
30 mg of extract was re-extracted with 5 mL of diethyl ether to divide it into two fractions (soluble and insoluble). Insoluble fraction of diethyl ether then added into 5 mL of water in a test tube then they were shaken. Positive test result indicated by for about 1-3 cm foam production in 15 minutes (Harborne, 1996).

Tannins
30 mg of the extract was added into hot water and boiled for 5 minutes. The mixture then filtered and the filtrate divided into 2 parts and each of it was added 1% of FeCl3. The presence of tannins and polyphenol were characterized by the formation of blue-green colour. Besides of that, the presence of tannins will characterized by the formation of a white precipitate after gelation addition (Harborne 1996).

Triterpenoids and Steroids
Saponin soluble fraction in diethyl ether separated and added with 10 drops of glacial CH3COOH and 2 drops of concentrated H2SO4. The solution was shaken slowly and was left for few minutes. Steroids gave blue or green colour, while triterpenoids gave red or purple colour (Harborne 1996).

Tested Microorganism
Four enteropathogenic bacterial strains were used in this study: EPEC, P. aerugionosa, S. aureus, and Shigella sp. These bacteria were obtained from Microbiology Laboratory, Bangka Belitung University, Indonesia. Bacterial strains were cultivated at 37°C and maintained on Nutrient Agar (NA) slant (Oxoid, USA) at 4°C.

Antimicrobial activity assay
Antimicrobial activity of extracts was determined by observation of their ability against four pathogenic bacteria using disc diffusion method. Crude ethanol extract and antibiotic (kanamycin as control) were dissolved in aquades. Extract and antibiotic were tested in three different concentrations (10mg/mL, 20 mg/mL, and 30 mg/mL). 20 ml of Nutrient Agar and 100 µL of bacteria suspension at log phase (10^7-10^8 cell/mL) were poured into petri dishes (90 mm each side), mixed, and homogenized. After agar medium solidified and innoculated, 6 mm diameter of antibiotic disc that had been soaked in extracts and antibiotic for 5 minutes then placed on the surface of the medium. Petri dishes were incubated at 37°C for 24 hour. Growth inhibition zone surround the disc represents the antimicrobial activity of extract. Negative control were paper disc soaked in aquades. The diameter of inhibition zone measured using digital Vernier

36

Journal of BIOLOGICAL RESEARCHES | Volume 21 | Number 1 | December | 2015
Caliper. Inhibition zone was calculated with reduce the total of inhibition with paper disc diameter (6 mm).

**RESULTS**

**Medicinal plant extracts**

The extraction using ethanol yielded different extract mass for each part of plants. Yield of *B. javanica* fruits extraction resulted 2.9% of extract, while root resulted 8.39% of extract. *W. androsaemofolia* fruits extraction resulted 11.21% of extract and 4.4% for leave.

<table>
<thead>
<tr>
<th>Table 1. Phytochemical component of each part of the plants</th>
<th>Compounds</th>
<th><em>B. javanica</em> fruits</th>
<th><em>B. javanica</em> roots</th>
<th><em>W. androsaemofolia</em> fruits</th>
<th><em>W. androsaemofolia</em> leaves</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkaloids</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Flavonoids</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Phenols</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Saponins</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Steroids</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Tannins and Poliphenols</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Triterpenoids</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Note: (+) = present, (-) = no

<table>
<thead>
<tr>
<th>Table 2. Inhibition Zone of Extracts investigated in diffusion assay</th>
<th>Extract/antibiotic</th>
<th>Concentration (mg/mL)</th>
<th>Means of Inhibition zone (mm) against</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>EPEC</td>
<td>P.a.</td>
</tr>
<tr>
<td><em>B. javanica</em> Fruits</td>
<td>10</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td><em>B. javanica</em> leaves</td>
<td>10</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td><em>W. androsaemofolia</em> Fruits</td>
<td>10</td>
<td>11.13±1.3</td>
<td>13.47±2.5</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>15.39±1.0</td>
<td>14.54±0.8</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>12.63±1.1</td>
<td>14.17±1.7</td>
</tr>
<tr>
<td><em>W. androsaemofolia</em> leaves</td>
<td>10</td>
<td>17.33±2.5</td>
<td>12.24±0.7</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>19.36±0.9</td>
<td>13.07±0.4</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>20.55±1.5</td>
<td>14.74±2.2</td>
</tr>
<tr>
<td>Kanamycin</td>
<td>30</td>
<td>15.3±0.6</td>
<td>23.58±5.6*</td>
</tr>
</tbody>
</table>

Note: *=the highest inhibition zone against tested bacteria

**Antibacterial Test Result**

Antibacterial activity test results show that ethanol extract of *W. androsaemofolia* could inhibit the growth of enteropathogenic bacteria effectively. At the concentration of 10, 20, 30 mg/mL, *B. javanica* extract could not inhibit the growth of enteropathogenic bacteria (Table 2). *W. androsaemofolia* leaves performed the widest inhibition zone against EPEC (20.55±1.5 mm) and *S. aureus* (22.14±4.5 mm) even when it compared to kanamycin (15.3±0.6 mm for EPEC and 19.61±6.0 mm for *S. aureus*) at concentration 30 mg/mL.

Although, *W. androsaemofolia* fruit extract could not perform better inhibition zone compared to kanamycin, but Duncan Multiple Range Test (DMRT) result showed that *W. androsaemofolia* fruit against *Shigella* sp. delivered similar wide of inhibition zones as *W. androsaemofolia* leaf against EPEC and *S. aureus* (Table 3).

**DISCUSSION**

Both ethanol crude extract of *B. javanica* fruit and leaf could not inhibit the growth of EPEC, *P. aeruginosa*, *S. aureus*, and *Shigella* sp. *B. javanica* is called as belilik in Bangka, it is called makassar fruit in other province in Indonesia, and Ya- and -Zi in China. It is widely used to treat cancer. It also can perform as anti-pyretic, detoxification, anti-inflammatory, and anti-virus with low level of toxicity (Chen et al, 2013).

**The results of phytochemical test**

Phytochemical analysis through qualitative method indicated that *B. javanica* fruit contain alkaloids, flavonoids, and phenols. In addition, *B. javanica* root contain alkaloids, phenols, and saponins. Phytochemical test of *W. androsaemofolia* showed that phenols, saponins and steroids are contained in fruit, while leaves contained phenols and steroids (Table 1).
contain brusatol and bruceine (A, B, C, E, F, G, H). Flesh of *B. javanica* fruit contains fatty oil, oleic acid, linoleic acid, stearic acid, and palmitic acid. Moreover, the most abundance active compound found in its fruit was brucein (Wijayakusuma, 2008; Chen et al., 2013).

Although, *B. javanica* contain antimicrobial compound, as the matter of fact it could not inhibit bacterial growth that tested in this study. It can be expected that the increasing of extract concentration and usage of another solvent for both fruits and leaves of *B. javanica* might be able to inhibit the growth of tested bacteria. It supported by Senthilnath et al., (2013) study that stated plant extracts contain antibacterial substances in sufficient concentrations that will kill bacteria effectively. It also possible that active compounds contained in extracts are not soluble in solvent that used in the study.

Sornwatana et al., (2013) stated that brucin, an antibacterial peptide derived from fruit of *B. javanica* showed antibacterial activity potential against *S. pyogenes*. Rahayu et al. (2009) stated that extract of *B. javanica* through soxhletation is more effective than extract derived from maceration at 30%, 60%, 90% concentration against *Shigella dysenteriae* ATCC 9361 through in vitro method. *W. androsaemofolia* performed inhibition activity to the growth of all tested bacteria, both gram-positive and gram-negative. The inhibition zone of plant extracts against both gram-positive and gram-negative bacteria may correlate to the presence of broad antibiotic compounds (Lans et al., 2001). *W. androsaemofolia* leaf extract showed the best inhibition against EPEC and *S. aureus* at concentration of 30mg/mL, it remains the same when it was compared to kanamycin at the same concentration. *W. androsaemofolia* fruit extract performed good inhibition to *Shigella* sp. DMRT showed that the ability of *W. androsaemofolia* fruit extract to inhibit *Shigella* sp. is similar to *W. androsaemofolia* leaf extract in inhibition of EPEC and *S.aureus* growth (Table 3 and Figure 1). The effect of both leaf and fruit extract of *W. androsaemofolia* against four tested bacteria were different (Table 2.), but *W. androsaemofolia* generally can inhibit growth of both gram-positive and gram-negative bacteria.

Gywali et al., (2013) stated that the activity of antimicrobial agents depend on microorganism types. Gram-positive bacterial cell walls contain peptidoglycan and teichoic or teichuronic acid, also this bacteria may or may not be surrounded by protein or polysaccharide envelope. Gram-negative bacterial cell walls contain peptidoglycan, lipopolysaccharide, lipoprotein, phospholipid, and protein. The critical attack site of antimicrobial agents is peptidoglycan layer. This layer is essential for bacterial survival in hypotonic environments. As the matter of this fact, loss or damage of this layer will alter bacterial cell wall rigid that lead to cell death. Outer layer of gram-positive and gram-negative bacteria cell wall and porin channels of Gram-negative bacteria allow antimicrobial agents diffuse easily through them. Gram-positive bacteria outer wall channels are loose, whereas gram-negative bacteria outer wall channels are narrow (Harold et al., 1996). It can be assumed that both leaf and fruit extract of *W. androsaemofolia* cause cell wall damage of gram-positive and gram-negative bacteria, due to the extracts ability to inhibit the growth of both gram-positive bacteria (*S. aureus*) and gram-negative bacteria (EPEC, *Shigella* sp., and *P. aeruginosa*).

Chinese traditional medicine apply *Wikstroemia* as antioxidant, antimicrobial, anti-inflammation, antivirus, antitumor, anticancer, and antibrowning (Huang et al., 2010; Lu et al., 2011; Li et al., 2012; Lu et al., 2012; Ko et al., 2013). Some studies reported that *Wikstroemia* contain flavonoids, biflavonoids, coumarin, aethic oil, lignan, polysacharide, and other important compounds (Huang et al., 2010; Li et al., 2010; Li et al., 2012; Ko et al., 2013; Lu et al., 2011; Lu et al., 2012). *Wikstroemia* contain flavonoid/biflavonoid, such as Naringin, 5,6,7-Trihydroxy-4’-methoxy-dihydroflavonol,kaempferol-3-O-b-D-ucopyra noside, kaempferol-3-robinoside-7-rhamnoside, wistrol

---

**Figure 1.** Inhibition zone caused by *W. androsaemofolia* a. leaves against EPEC b. fruits against Shigella sp.
A, wikstrol B, chamaejasmin, neochamaejasmin, isoacha-
mejasmin, chamaehromone, genkwanin, quercetin, quercitrin, sikokianin B, sikokianin C, sikokianin D, stel-
leranol, genkwanol C, genkwanol B, tricin, and 4’-
methoxydaphnodorin (Li et al, 2005; Huang et al, 2010; 
Chen et al, 2012; Li et al, 2012; Wei et al, 2012; Yongqin 
that Wikstroemia indica extract through decoction showed 
bacterial activity against Bacillus coli, Staphylococcus 
aureus, Bacillus subtilis, and Sarcina lutea using the dou-
bling dilution method. The minimum inhibitory concen-
tration (MIC) of Bacillus coli, Staphylococcus aureus, 
Bacillus subtilis, and Sarcina lutea were 156mg/mL, 
78mg/mL, 78mg/mL and 39mg/mL, respectively. Fur-
thermore, the minimum bactericidal concentration (MBC) 
of these four species of bacteria were 312mg/mL, 
156mg/mL, 156mg/mL and 78mg/mL, respectively. In 
conclusion, antibacterial activity performance can be 
classified from strong to weak as follow Sarcina lutea, Staph-
ylococcus aureus, Bacillus subtilis, and Bacillus coli.

Both leaf and fruit extracts of W. androsaemifolia showed 
difference ability against tested bacteria, which probably 
influenced by different compound contained in each 
extract. Arulmozhi et al (2007) stated that the anti-
bacterial properties of medicinal plants correlated to the 
presence of chemical agents contain which commonly 
called as bioactive antimicrobial compounds. Different 
concentration of extract showed different ability to form 
inhibition zone. Yang & Zu (2006) stated that antibacteri-
al activity depend on the concentration of substances.

The effectiveness of medicinal plant in curing dis-
ease is noticeably due to the combination of different 
compounds activities originally in the plant (Bhandarkar 
et al., 2003). Phenol compounds have capacity to link 
with proteins and bacterial cell membrane then form 
complexes (Zongo et al, 2011). Steroids have been re-
ported to have antibacterial properties by link to the cell 
membrane lipids, for the consequences it will alter 
membrane sensitivity for steroidal compound associated 
with liposomes leakages (Raquel et al., 2007). Antimicrobial 
property of saponin is related to its ability to stimulate 
leakage of several proteins and certain enzymes from the 
cell (Zablotowicz et al., 1996).

The best concentration to inhibit the growth enter-
opathogenic bacteria was 30 mg/mL after compared to 
commercial antibiotic aminoglycoside kanamycin at the 
same concentration. Aminoglycosides are complex sugars 
connected to glycosidic linkage. Antimicrobial activity of 
these agents are depend on the free NH₃ and OH groups, 
which aminoglycosides bind to specific ribosomal pro-
teins (Harold et al, 1996). Bactericidal effect of the ami-
oglycoside kanamycin has been investigated extensively, 
it irreversibly binds to 16S of 30S ribosomal subunit 
(Franklin & Snow 2005). In addition, in order to targeting 
the protein synthesis machinery, kanamycin inhibit DNA 
synthesis and cellular membrane composition. The in-
crease of glucose incorporation lipids and hydrophobic 
into the membrane fraction showed that cellular mem-
brane was also damaged by kanamycin treatment (Faraji 
et al, 2006).

As has been noted, W. androsaemifolia can be used 
as alternative antimicrobial agents in new drugs develop-
ment for infectious diseases caused by enteropathogenic 
bacteria especially EPEC, S. aureus, and Shigella sp. 
Therefore, the enhancement of plant extracts activity, in 
particular by using another solvent, extraction techniques, 
or purification are needed for further investigation. It is 
also necessary to ensure the safety of plant extracts before 
widely used.

ACKNOWLEDGEMENT

The author would like to thank to Umajaya and Yu-
liana who assisted in Brucia javanica antibacterial activi-
ty test in Microbiology Laboratory, Bangka Belitung 
University.

REFERENCES

Adelia N. 2010. Pengetahuan Tradisional Tentang Pemanfaatan Tumbuhan Obat oleh Masyarakat Suku Lom di Dasun Air Abik de-
sa Gunung Muda Kecamatan Belinyu Bangka [skripsi]. Bang-
ka: Universitas Bangka Belitung.

Anand SP., Doss A., Nandagopalan V. 2011. Antibacterial studies on 
leaves of Clitoria ternatea Linn – a high potential medicinal 
plant. International Journal of Applied Biology and 

Arulmozhi S., Mazumder PM., Ashok P., Narayanan LS. 2007. Pharma-
cological activities of Alstonia scholaris Linn. (Apocynaceae)- 
A review. Pharmacognosy Review. 1: 163 165.

Lam. Against CC14 induced hepatic damage in albino rats. In-

Chen LY., Chen IS., Peng CF. 2012. Structural Elucidation and Bioac-
tivity of Biflavonoids from the Stems of Wikstroemia taiwanae-
nsis, Asian Natural Product Resources. 14 (4):401-6

Chemical components, Pharmacological properties, and nano-
particulate delivery systems of Brucia javanica. International 
Journal of Nanomedicine. 8: 85-92

Trubus Agriwidya: 28-33.

Dipankar C, Murugan S, Devi P.U.2011.Review on Medicinal and 
Pharmacological Properties of Irenea herbistsi, Chrozophora 
rottleri and Echolium linneanum. African Journal Traditional 

Faraji R., Parsa A., Torabi B. Withrow T. 2006. Effects of kanamycin on 
the Macromolecular Composition of kanamyin Sensitive 
Escherichia coli DH5! Strain. Journal of Experiment 
Microbiology and Immunology (JEMI). 9:31-36

Franklin TJ. and Snow GA. 2005. Biochemistry and molecular biology of 
antimicrobial drug action. 6th ed. Springer, Cheshire, Eng-
land

Gwyali R. et al. 2013. Antibacterial and cytotoxic activities of high 
altitude essential oils from Nepalase Himalaya. Journal of 
Medicinal Plants Resources. 7(13): 738-743

Harborne JB.1996. Metode Fisiokimia Penunutan Cara Modern 
Menganalisis Tumbuhan. Terbitan Kedua: Bandung. ITB

Harold CN. and Thomas DG. 1996. Medical Microbiology. 4th edi-
tion.Baron S. editor.Galveston (TX): University of Texas Med-
cal Branch at Galveston.

Hendriani and Hadiah JT. 1999. Koleksi Tumbuhan Obat Kebany 
Raya Bogor, Bogor: UPT Balai Pengembangan Kebany Raya Lemb-
bagai Ilmu Pengetahuan Indonesia.

Antiviral biflavonoid from radix Wikstroemia (Liaojugewang-

Ko YC, Feng HT, Lee RJ, Lee MR. 2013. The determination of plavo-
noids in Wikstroemia indica with photo-diode array detection 
and negative electrospray ionization tandem spectrometry. 
Antibacterial Activity of Belilik (Brucea javanica (L.) Merr) and Benta (Wikstroemia androsaemofolia Decne) to Inhibit The Enteropathogenic Bacteria

Kusmala D. 2012. Uji Efektititas Antibiotik yang Dihasilkan Cendawan Endotif dengan Beberapa Jenis Antibiotik Sintetek dalam Menghambat Pertumbuhan Bakteri Enteropatogenik Escherichia coli dan Pseudomonas aeruginosa. [skripsi]: Universitas Bangka Belitung


Li JI., Li C. 2010. Ultrasonic-microwave Synergistic Extraction and Antioxidant Activity of Total Flavonoids from Wikstroemia indica (Linn.) C.A. Mey [abstract]. Food Science: 16


Noveria I. 2012. Uji Efektititas Antibiotik yang Dihasilkan Cendawan Endotif dengan Antibiotik Sintetek dalam Menghambat Pertumbuhan Bakteri Staphylococcus aureus dan Shigella sp. [skripsi]: Universitas Bangka Belitung


Yang Z and Du Z. 2006. Study on antibacterial activity of Wikstroemia indica decoction (abstract) Journal of Harbin Medical University


